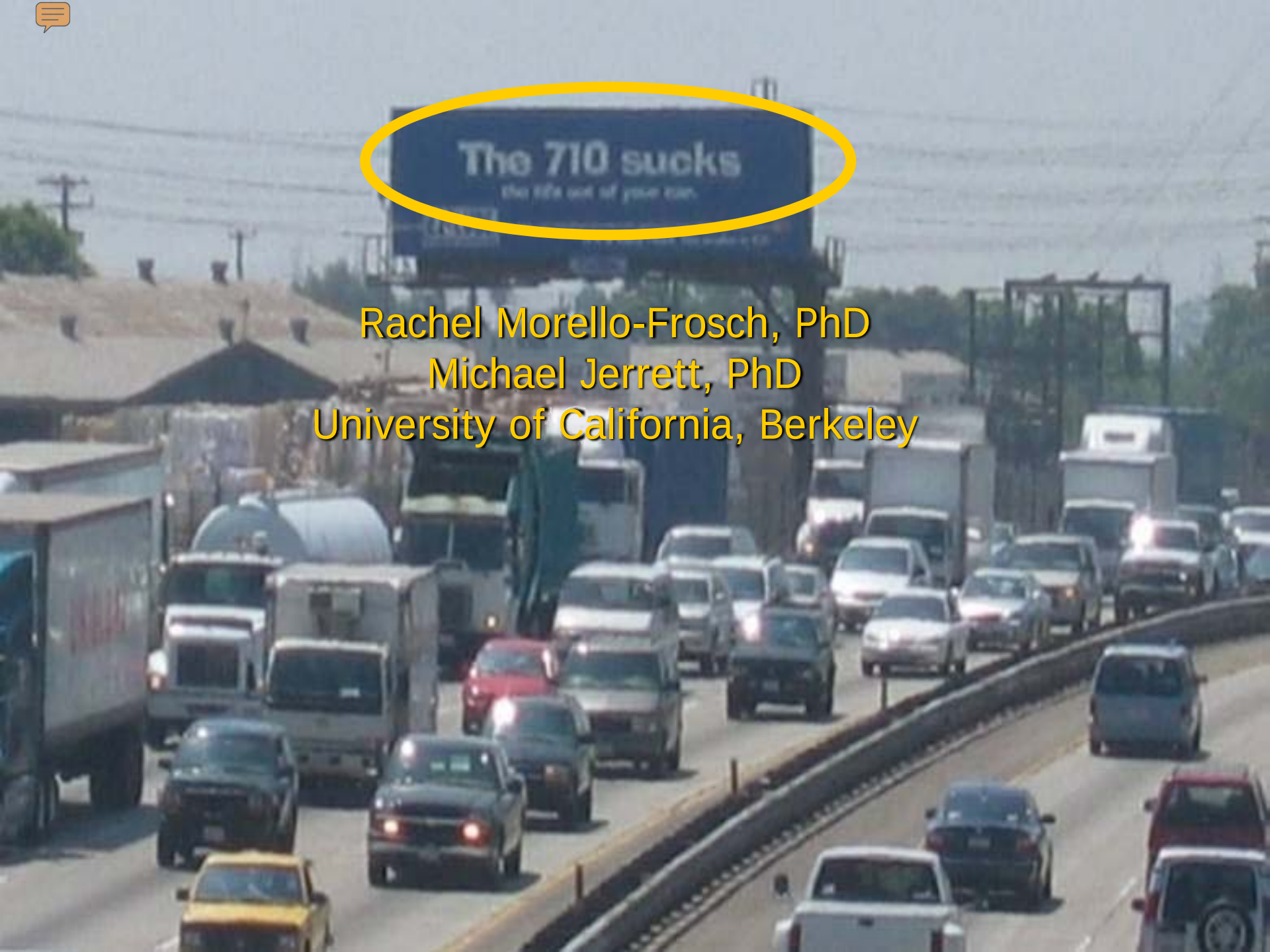
Scientific Research Relevant to Cumulative Environmental Impacts



Rachel Morello-Frosch, PhD
Michael Jerrett, PhD
University of California, Berkeley

Cumulative Impacts Analysis

To address:

- **Multiple exposures**

  in a geographic area from combined emissions and discharges, from all sources, whether single or multi-media, routinely, accidentally, or otherwise released

- **Susceptibility**

  to take into account sensitive populations and socio-economic factors

Adapted from CEJAC working definition of CI

Review of the Research Evidence

- Disparities in exposure
- Disparities in vulnerability and susceptibility
- Disparities in health effects of exposure by race, ethnicity and social position

Importance of Cumulative Impact: Triple Jeopardy Hypothesis

- Lower positioned groups face more *environmental hazard exposures*
- Same groups more *susceptible* due to poverty, age, poor nutrition, psycho-social stress, existing disease, etc.
- These groups less able to tolerate adverse exposures; therefore health effects are greater– leading to *cumulative impacts* and environmental health inequalities
  - Effect Modification
  - Interaction
  - Amplification

Cumulative Impact & Triple Jeopardy Hypothesis

Disparities in Exposures

Hazardous Occupations
Poor Ambient Air Quality
High Traffic Density
Poor Housing Quality

Disparities in Susceptibility

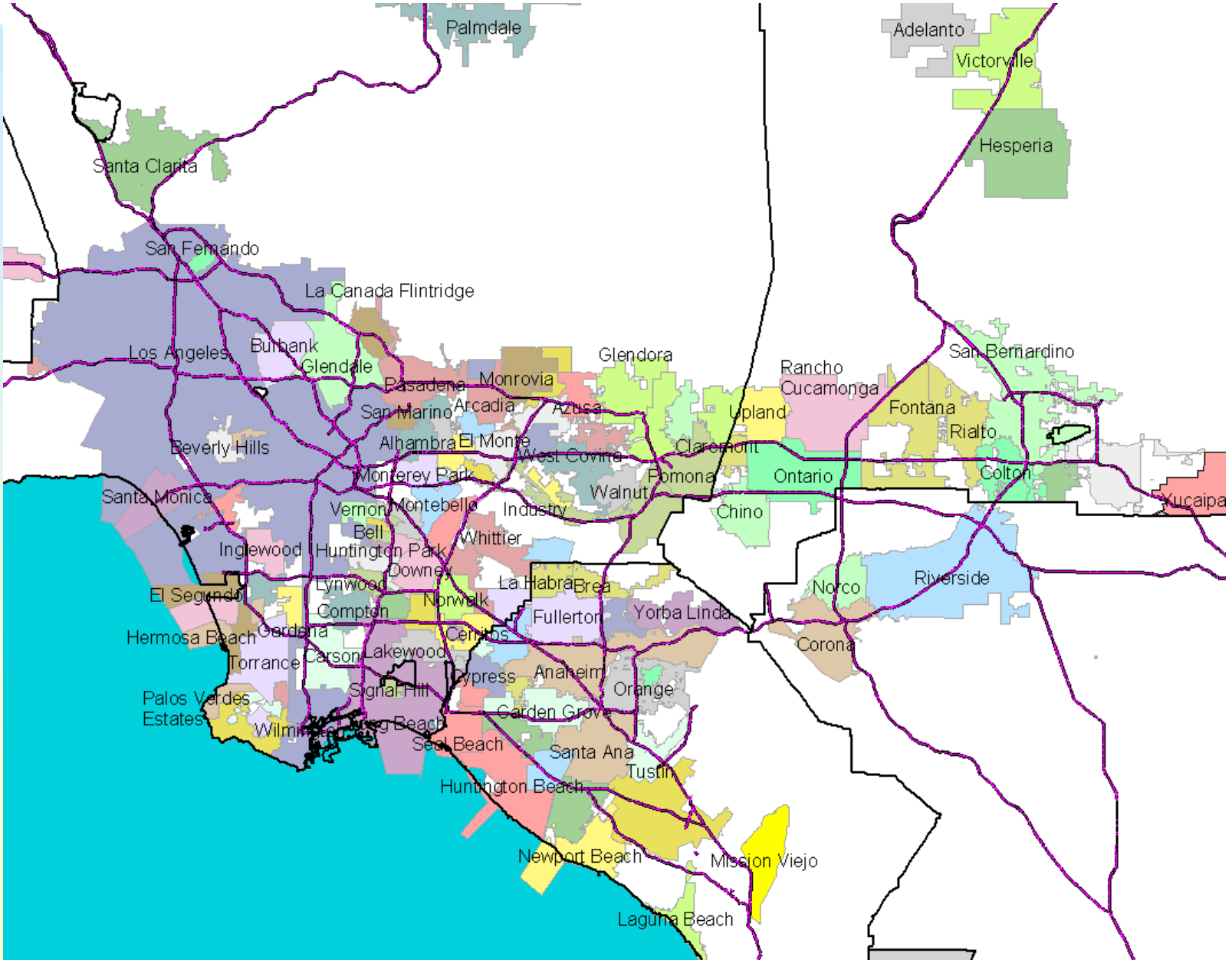
Poverty
Malnutrition
Psycho-social Stress
Less Health Care Access
Health Behaviors
Underlying Disease

Environmental Health Disparities

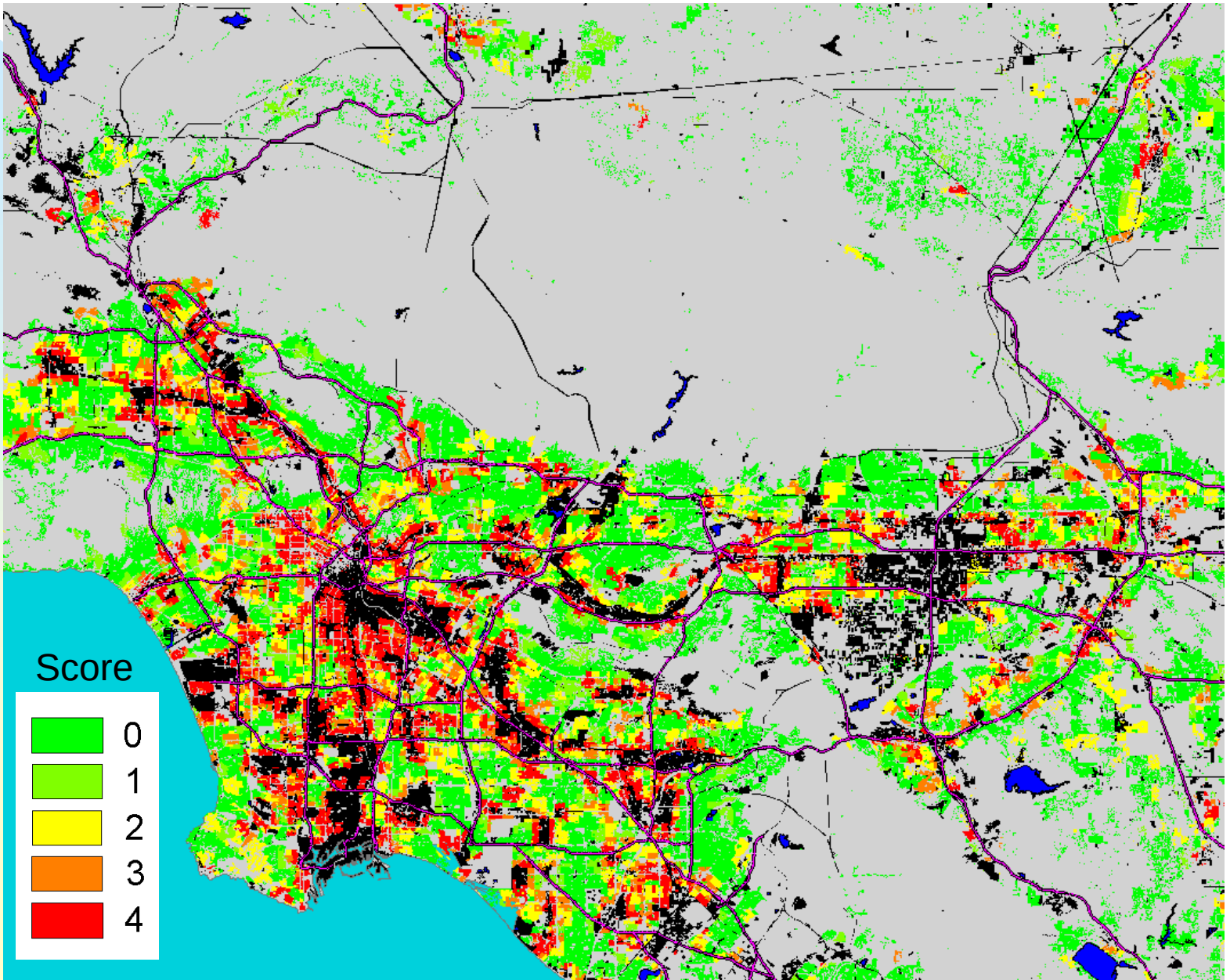
Mortality
Morbidity

Morello-Frosch et al., 2006
O'Neill et al. 2003
Jerrett, 2001
IOM, 1999

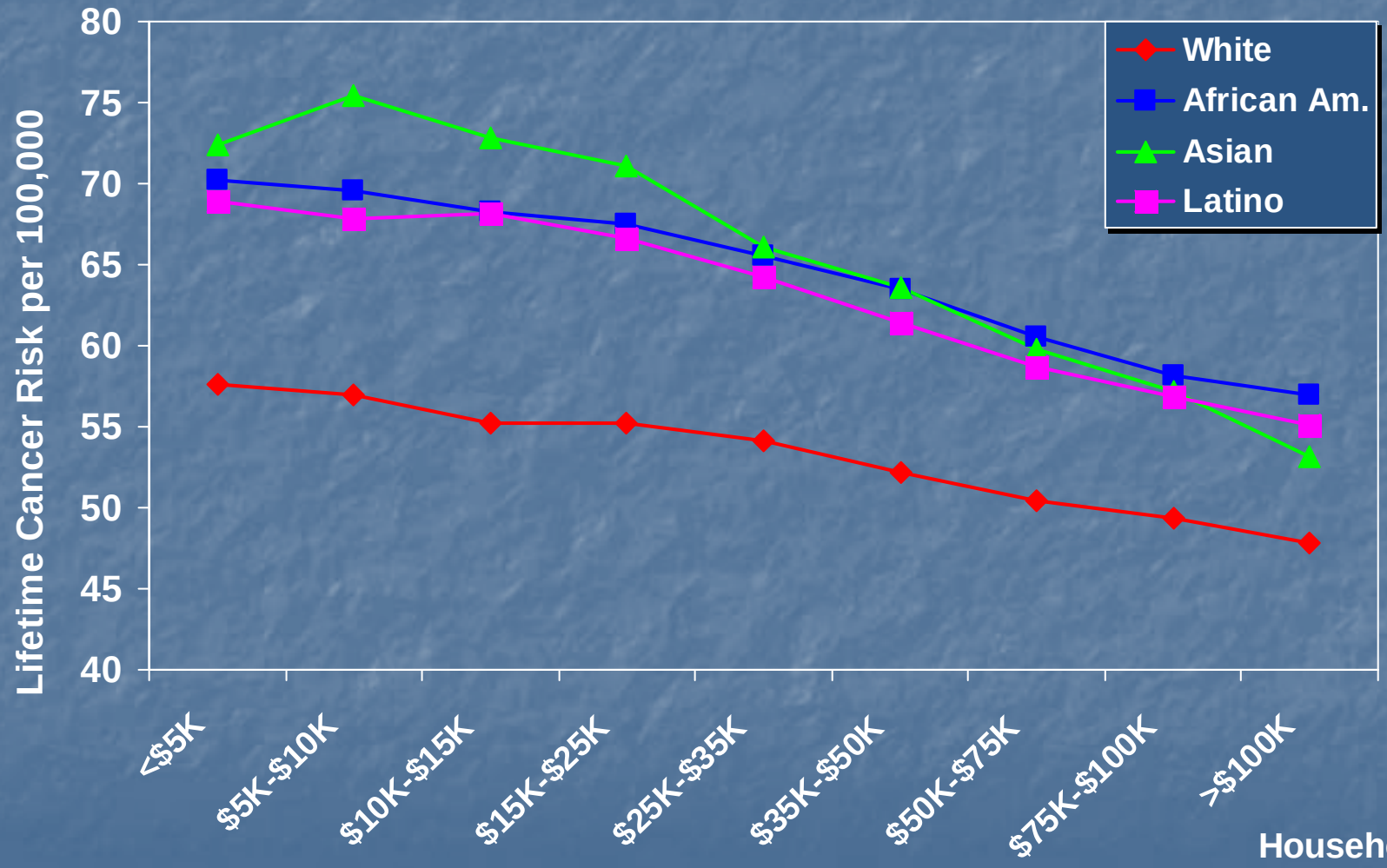
Southern California Cities



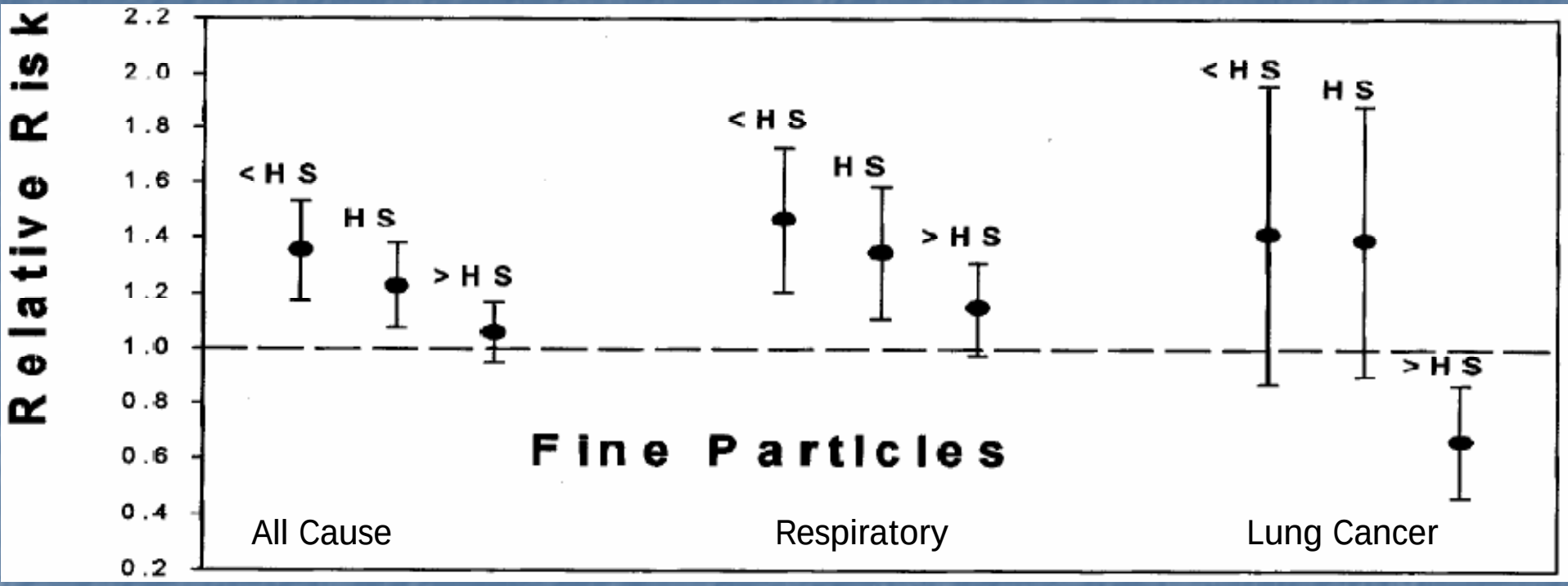
Disparities in Hazard Location – Southern CA



Disparity in Estimated Lifetime Cancer Risks from Ambient Air Toxics Exposures by Race/Ethnicity & Income South Coast Air Basin

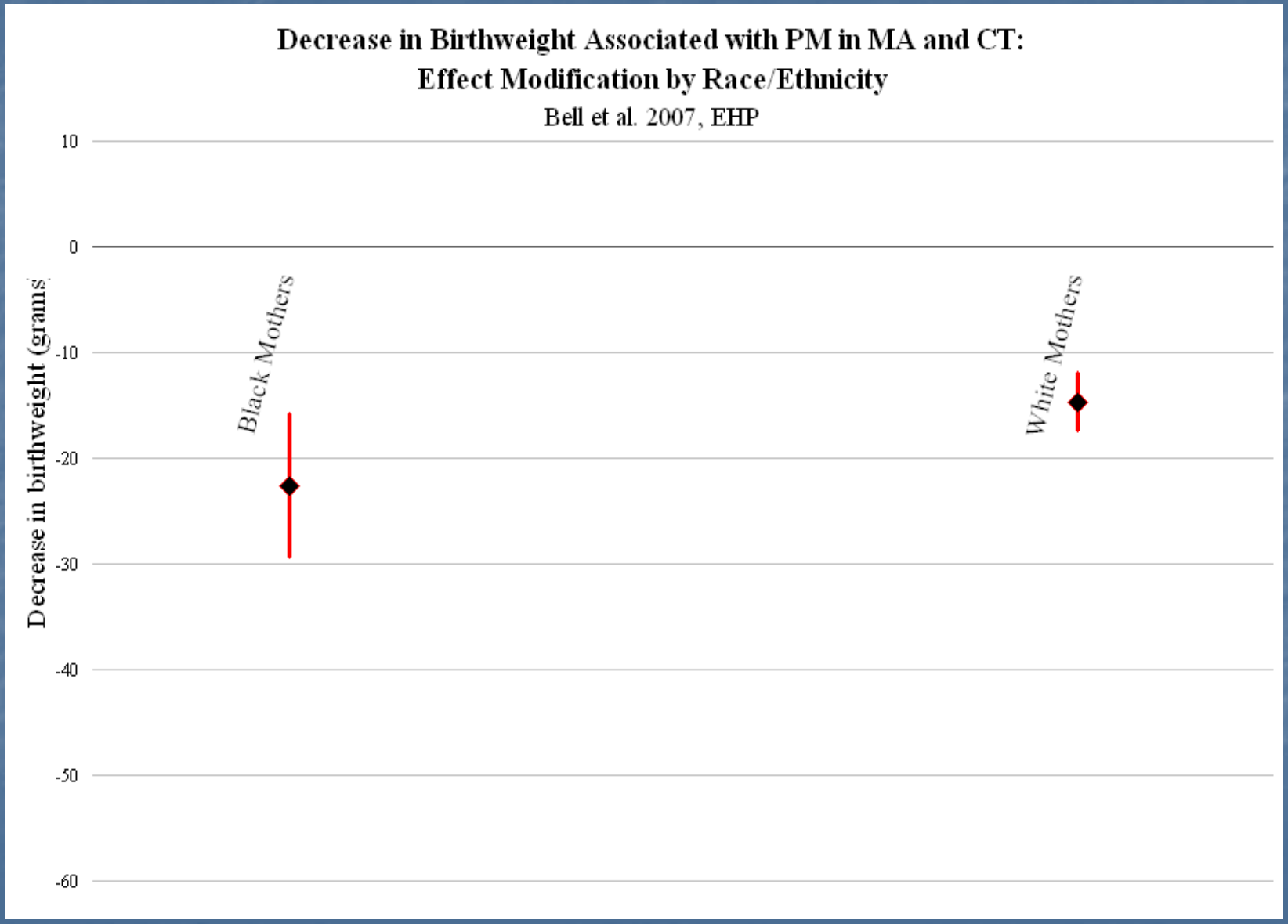


Effect Modification:
Mortality Risk of $PM_{2.5}$ Exposure by Education

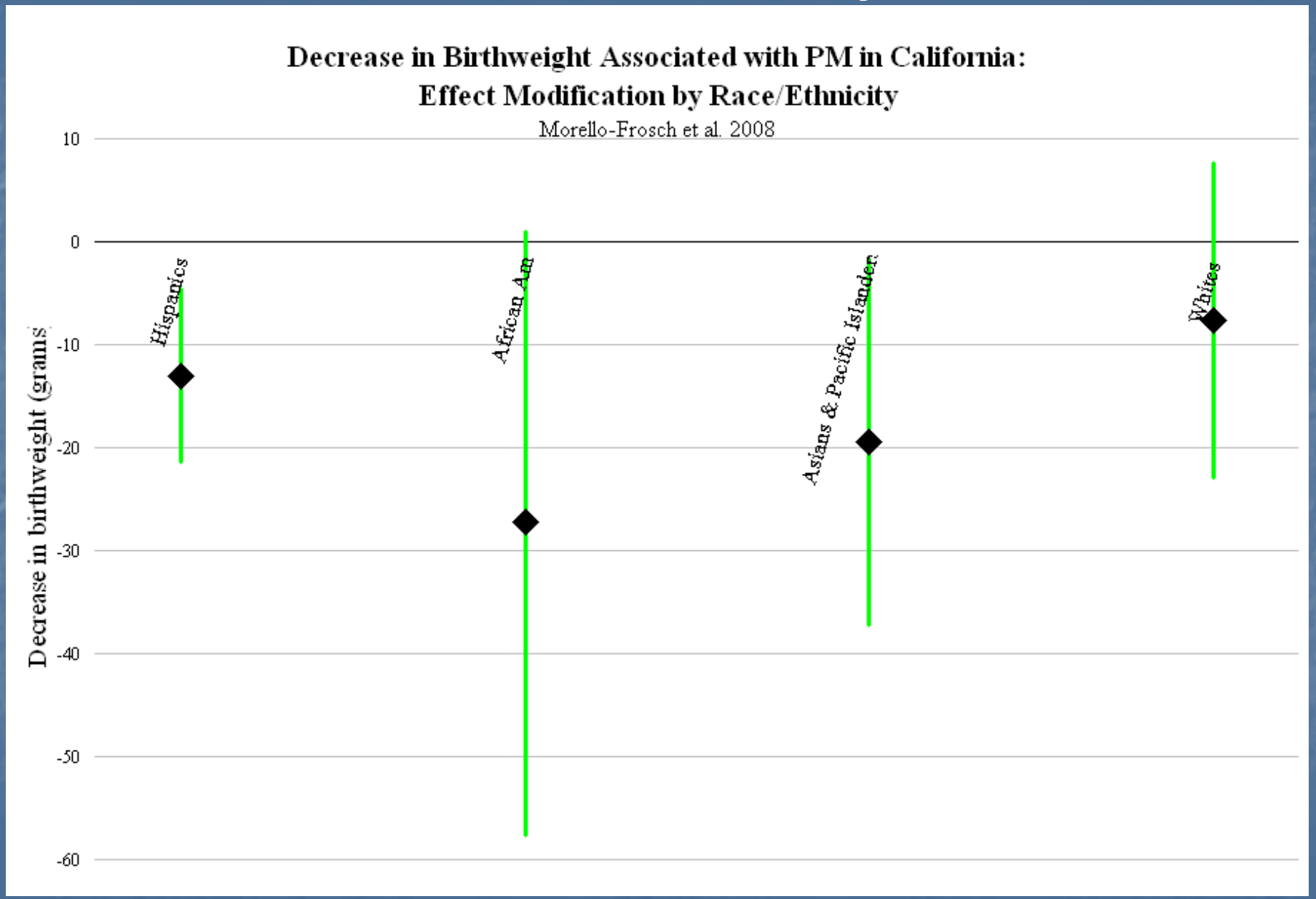


- Relative risk of dying over 8 years based on a 10 ug/m^3 increment in $PM_{2.5}$ exposure.
- Risks shown for persons with less than high school, high school, or postsecondary education.

Effect Modification by Race I

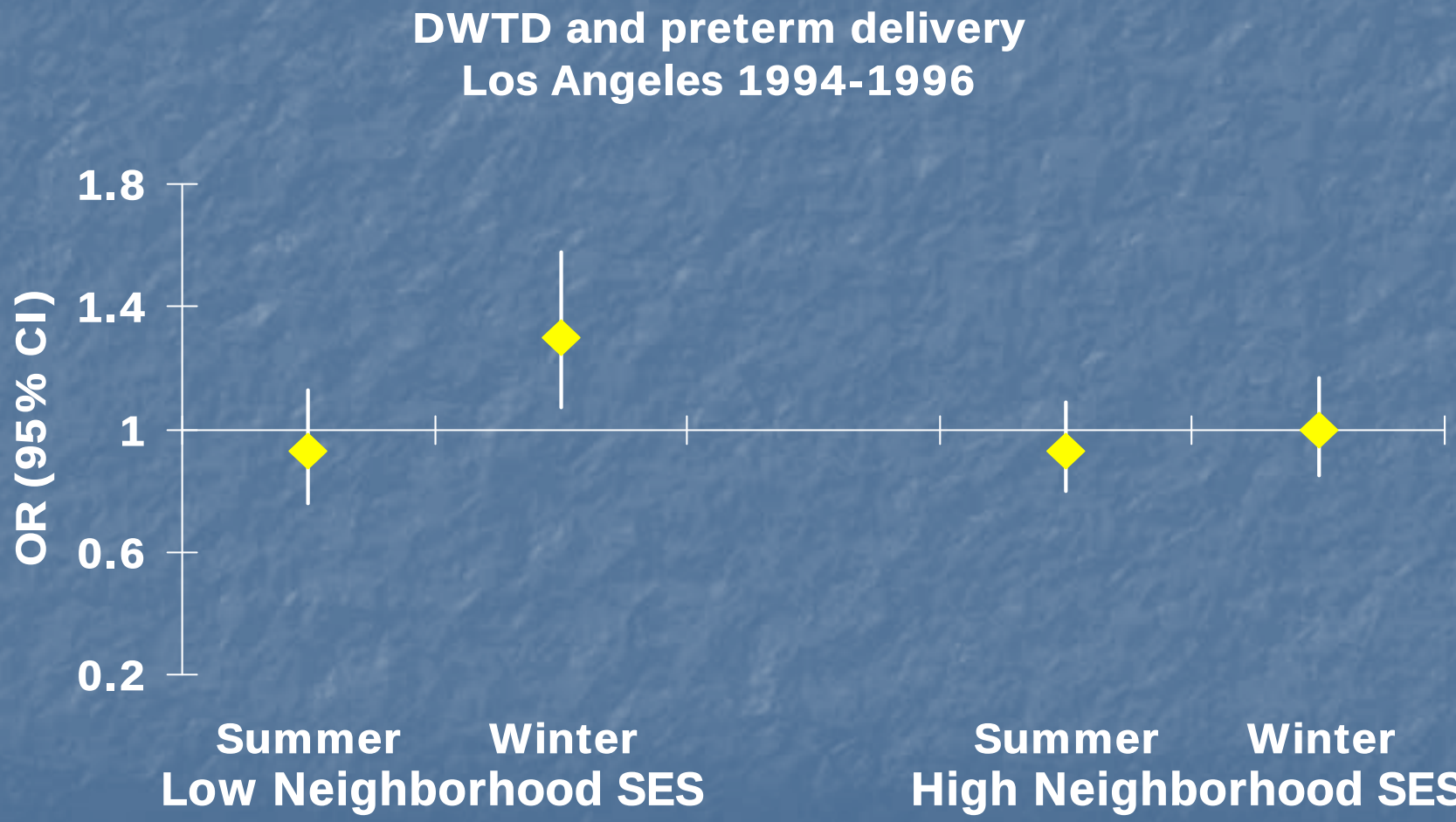


Effect Modification by Race II



Effect Modification by Neighborhood SES: Traffic Exposure and Risk of Pre-term Delivery

Ponce et al EHP (2005)

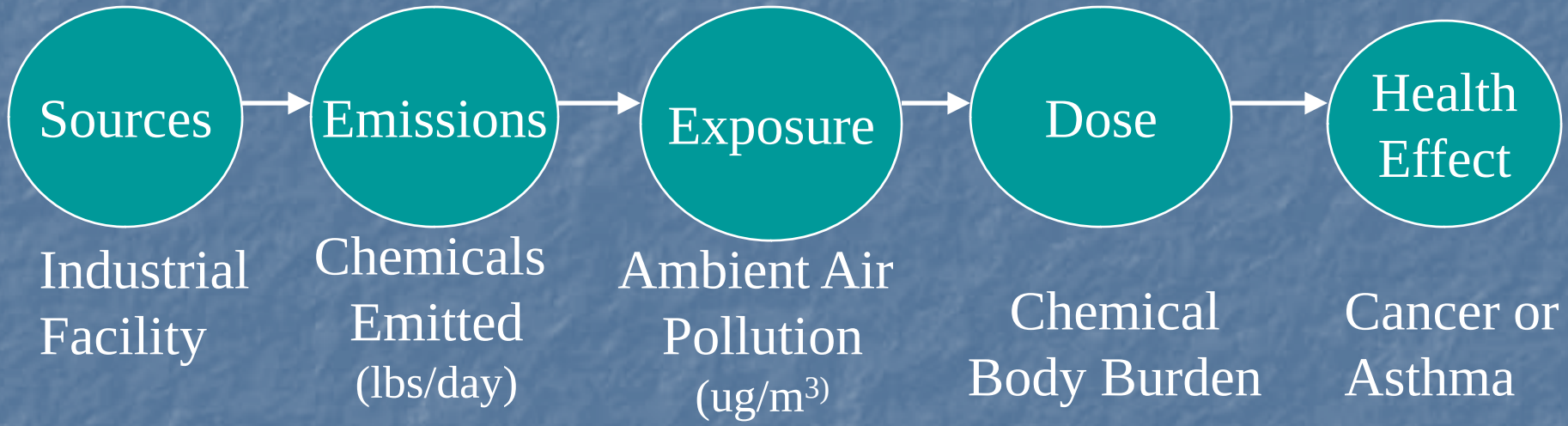


Slide, courtesy of JD Parker, NCHS

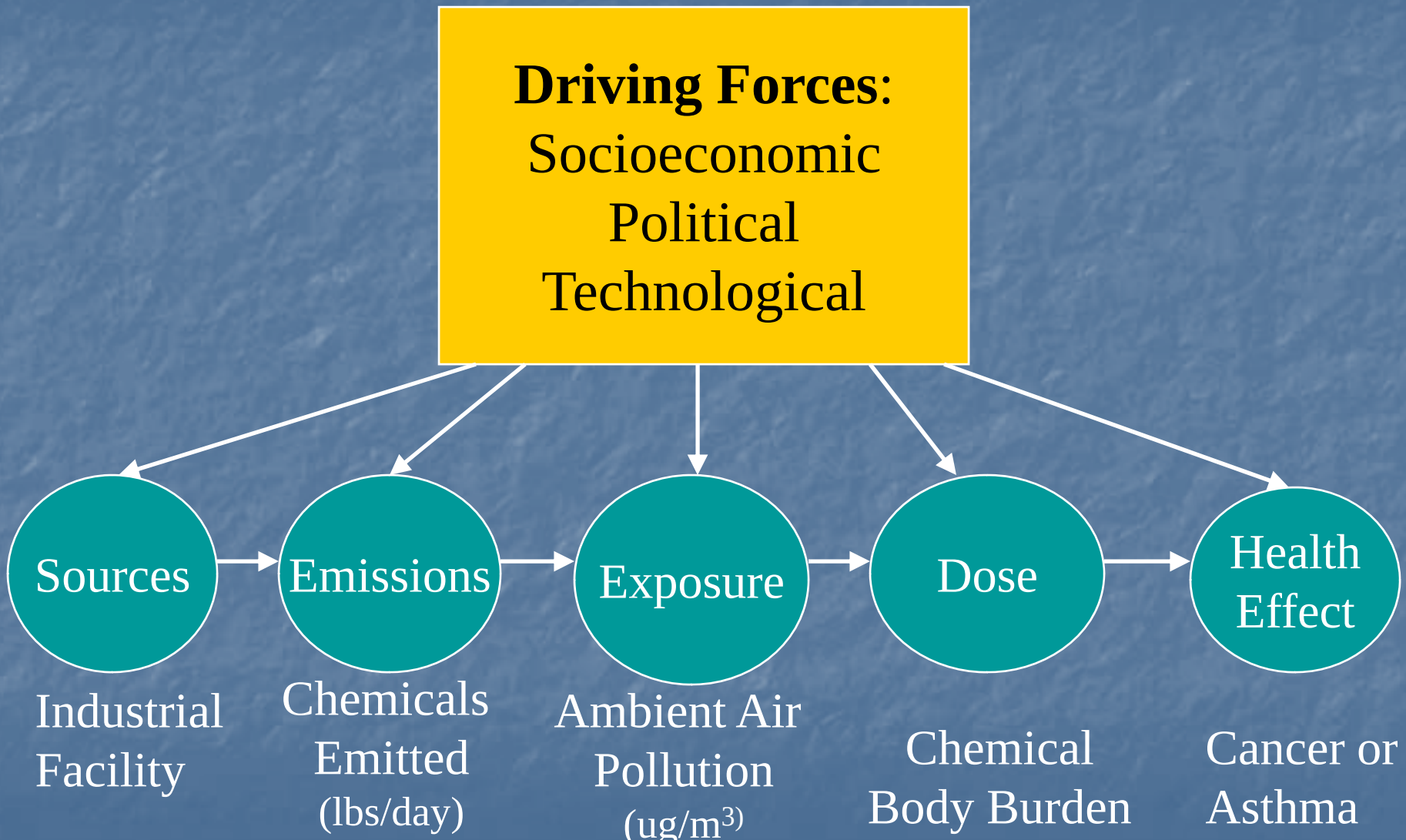
Moving Regulatory Science From

Understanding Links Across Exposure Health Outcome Continuum

To…

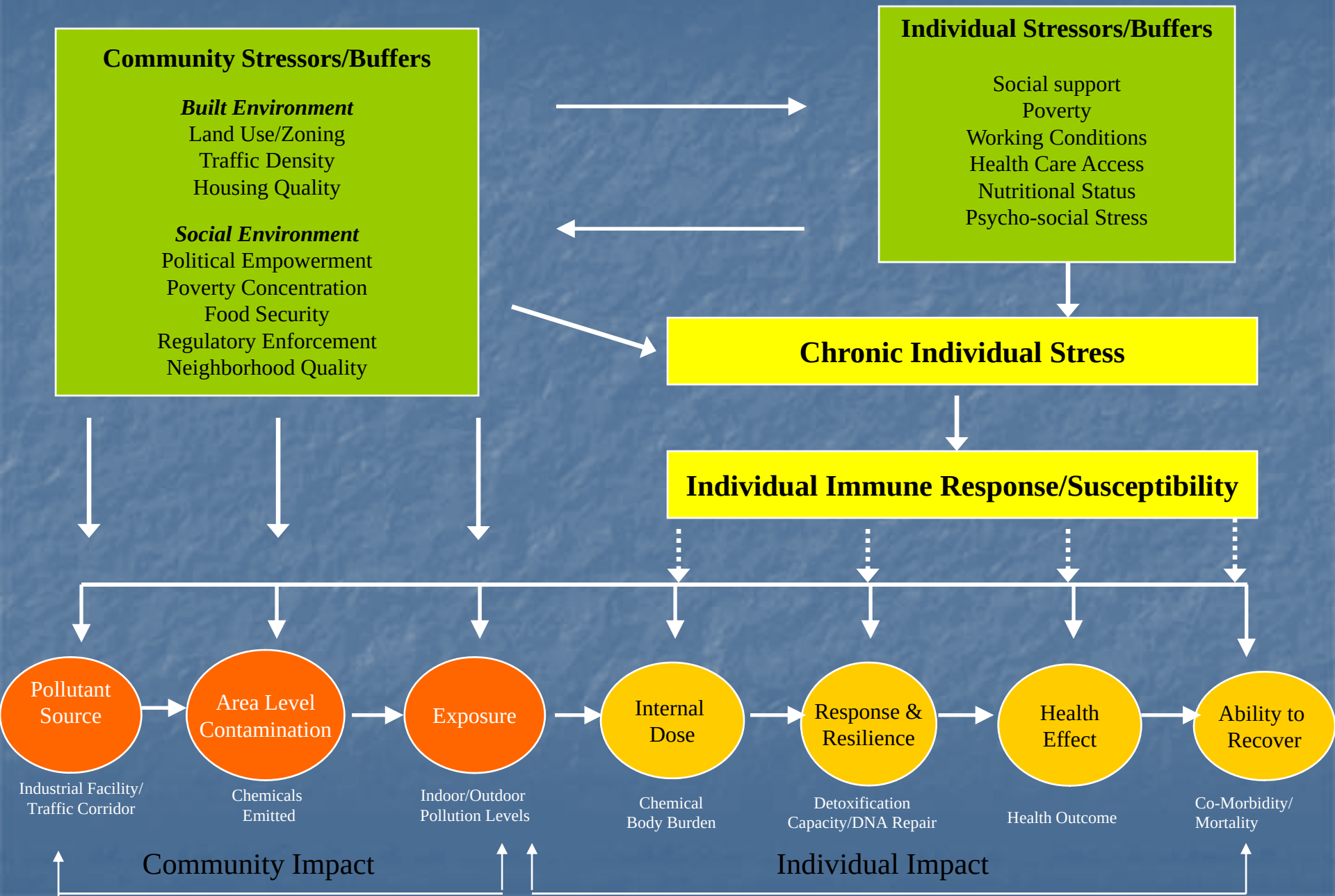


...Understanding Drivers of Cumulative Impact



Cumulative Impact: Putting the Pieces Together

(Adapted from Morello-Frosch & Shenassa, EHP, 2006)



Summary of Evidence for Cumulative Impacts Analysis

- Disparities in exposure are present in California
- People of color and the poor are more susceptible to exposures
- Health effects from pollutants generally stronger in these groups

Deriving Indicators of Cumulative Impact

Objectives:

- Facilitate cumulative impact (CI) analysis of environmental disparity in California
- Derive “indicators” for CI analysis that are transparent, yet scientifically sound
- Facilitate CI analysis capable of comparing impacts within and between jurisdictions
- Demonstrate validity of approach using existing data sources

Land Use Regression Modeling

TORONTO_ID	RD1-50km	RD2-50km	RD3-50km	RD1-50200km	RD2-50200km	RD3-50200km
2115	0	0.11	0.025	0	0.275	1.715
2160	0	0	0.275	0	0.405	1.38

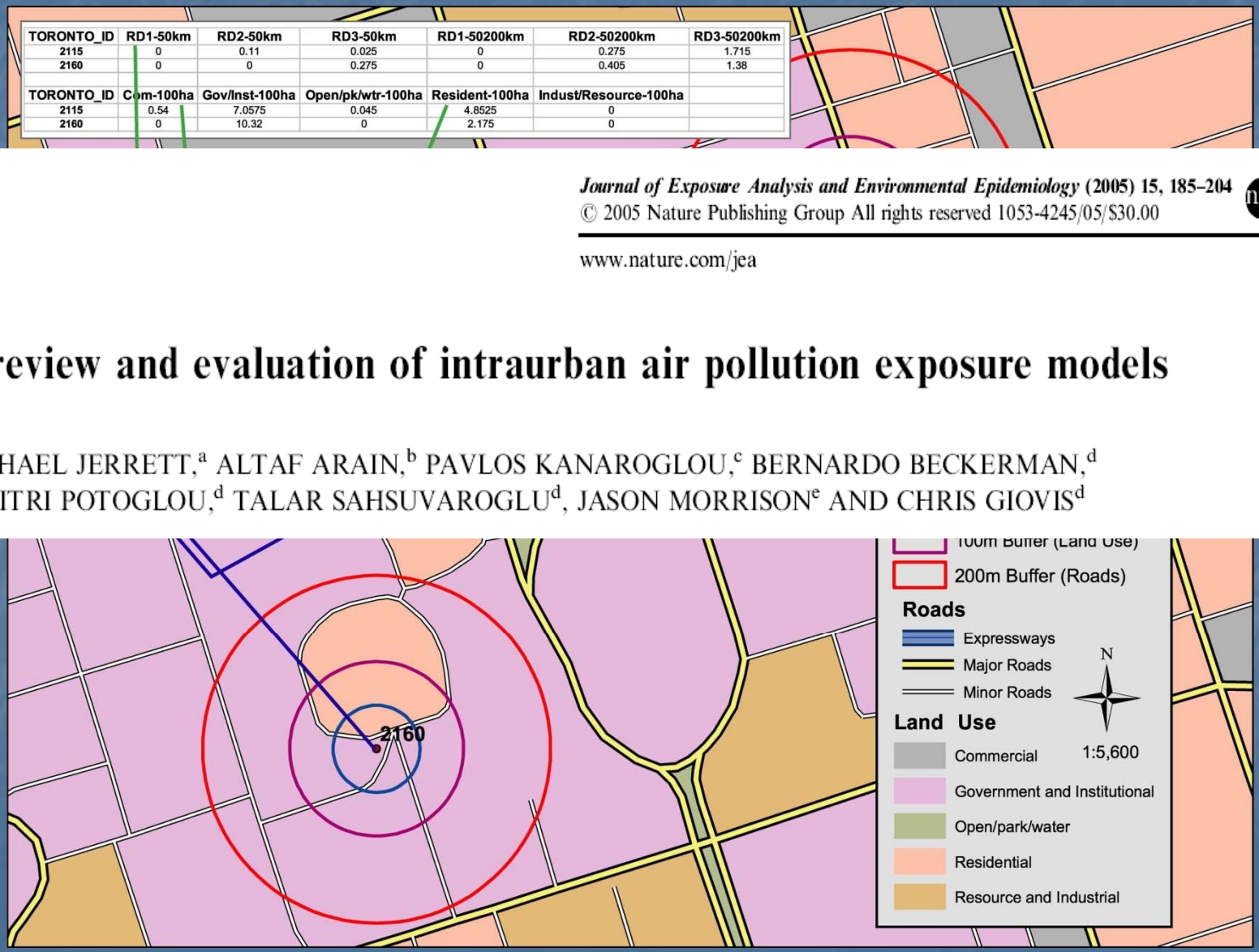
TORONTO_ID	Com-100ha	Gov/Inst-100ha	Open/pk/wtr-100ha	Resident-100ha	Indust/Resource-100ha
2115	0.54	7.0575	0.045	4.8525	0
2160	0	10.32	0	2.175	0

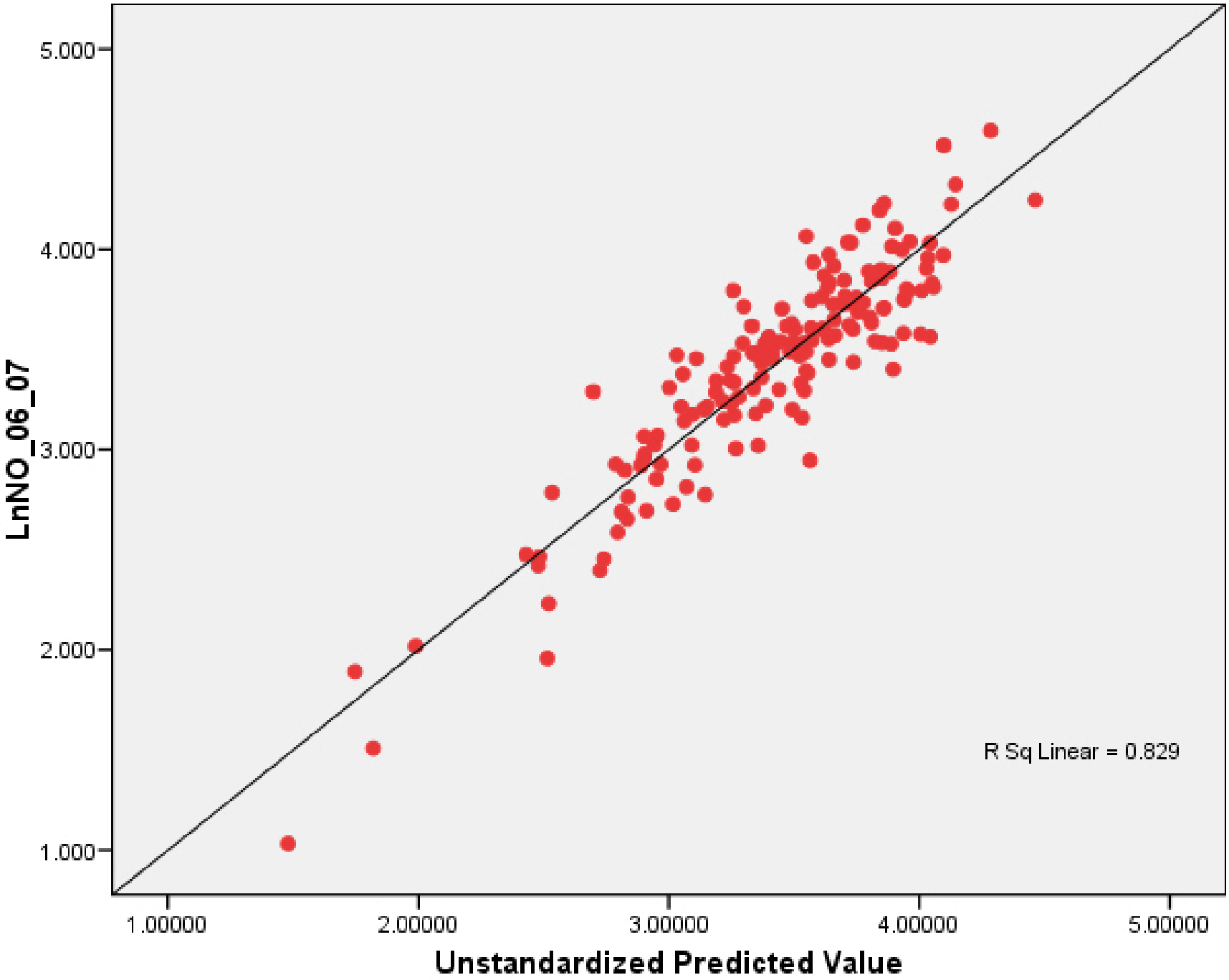
Journal of Exposure Analysis and Environmental Epidemiology (2005) 15, 185–204

www.nature.com/jea

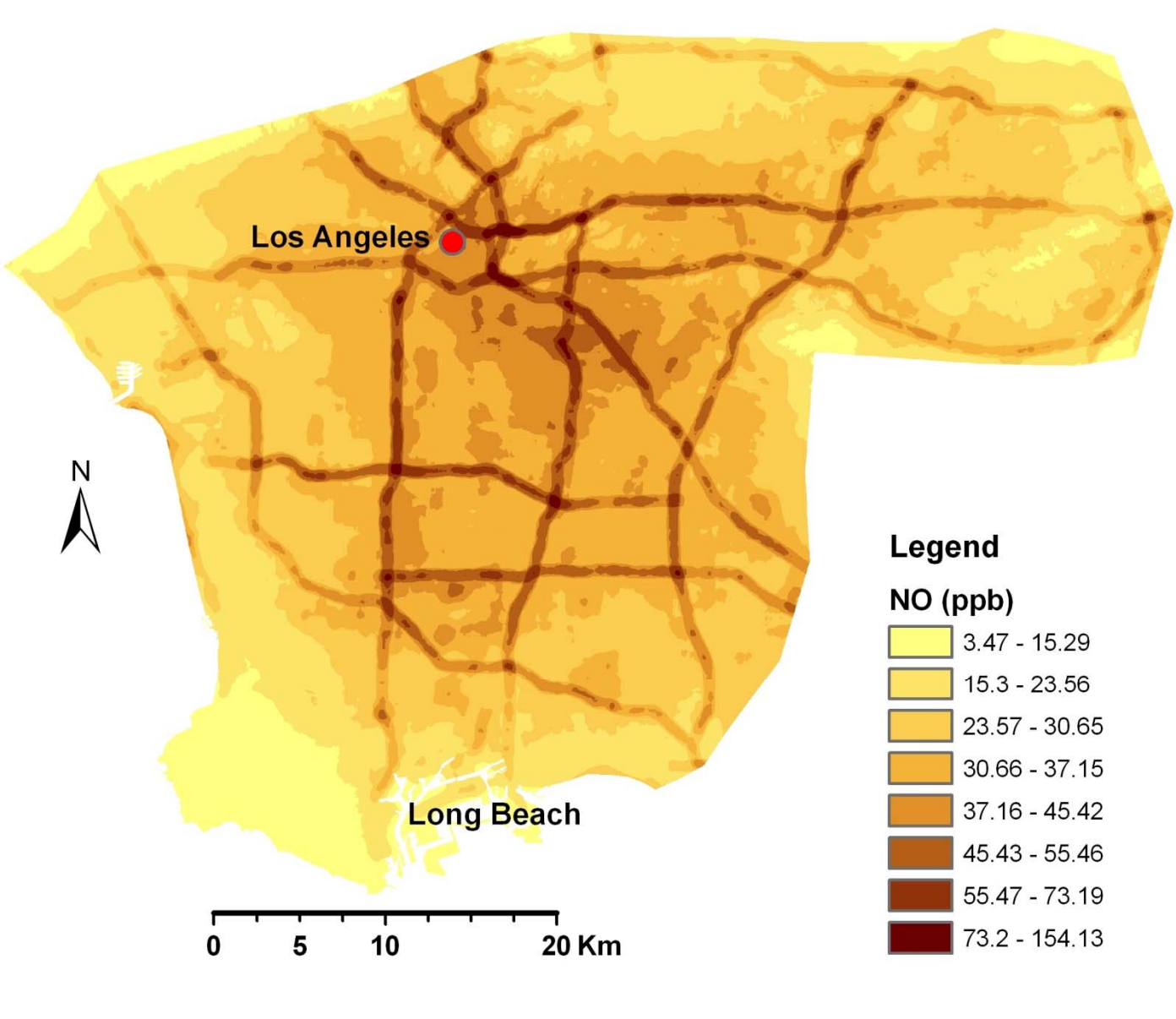
A review and evaluation of intraurban air pollution exposure models

MICHAEL JERRETT,[a] ALTAF ARAIN,[b] PAVLOS KANAROGLOU,[c] BERNARDO BECKERMAN,[d] DIMITRI POTOGLOU,[d] TALAR SAHSUVAROGLU[d], JASON MORRISON[e] AND CHRIS GIOVIS[d]

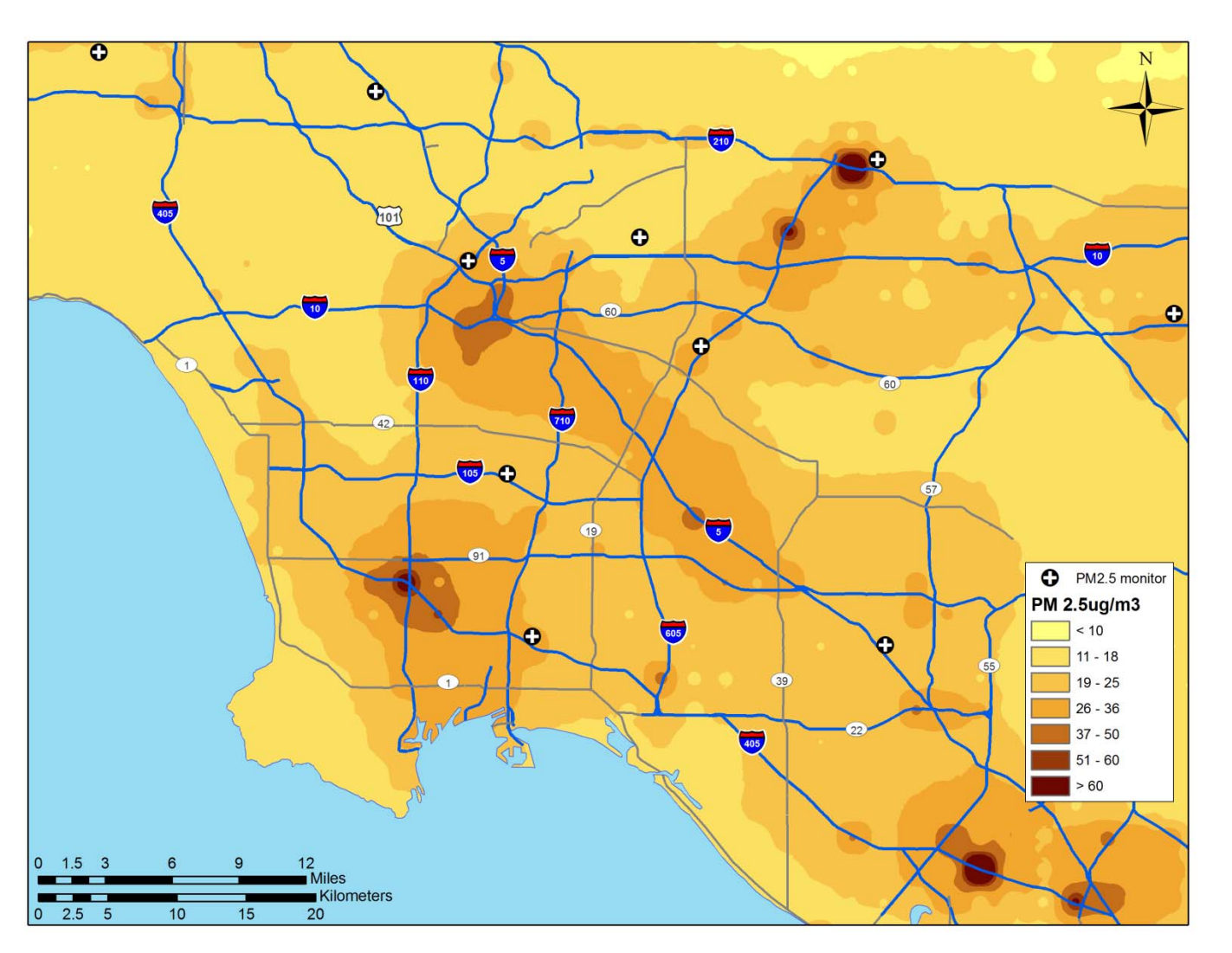



5.000
4.000
3.000
2.000
1.000
LnNO_06_07
1.00000
2.00000
3.00000
4.00000
5.00000
Unstandardized Predicted Value
R Sq Linear = 0.829

Nitrogen Oxide Pollution in Los Angeles: Fine-scale LUR Traffic Pollution Prediction

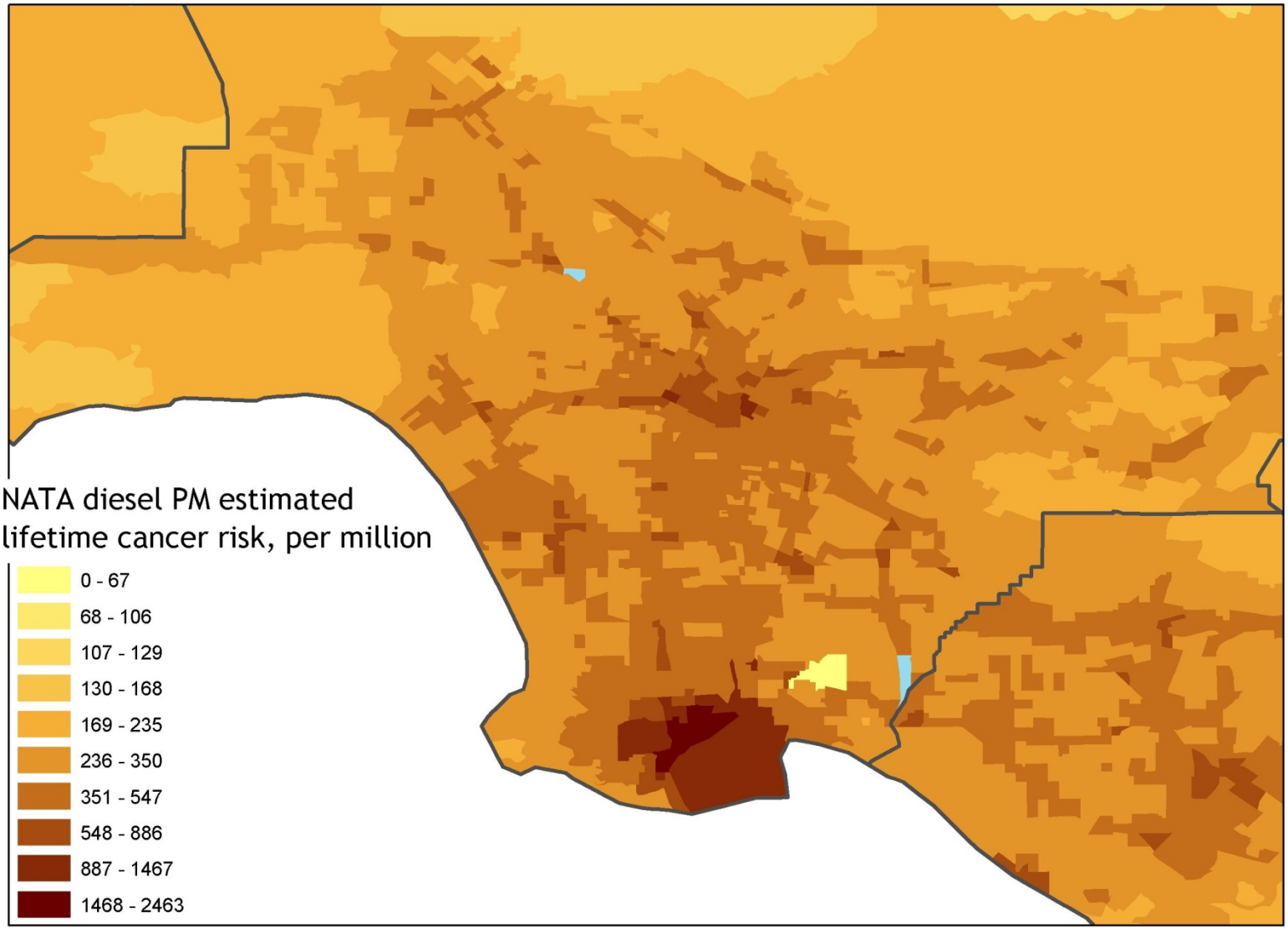


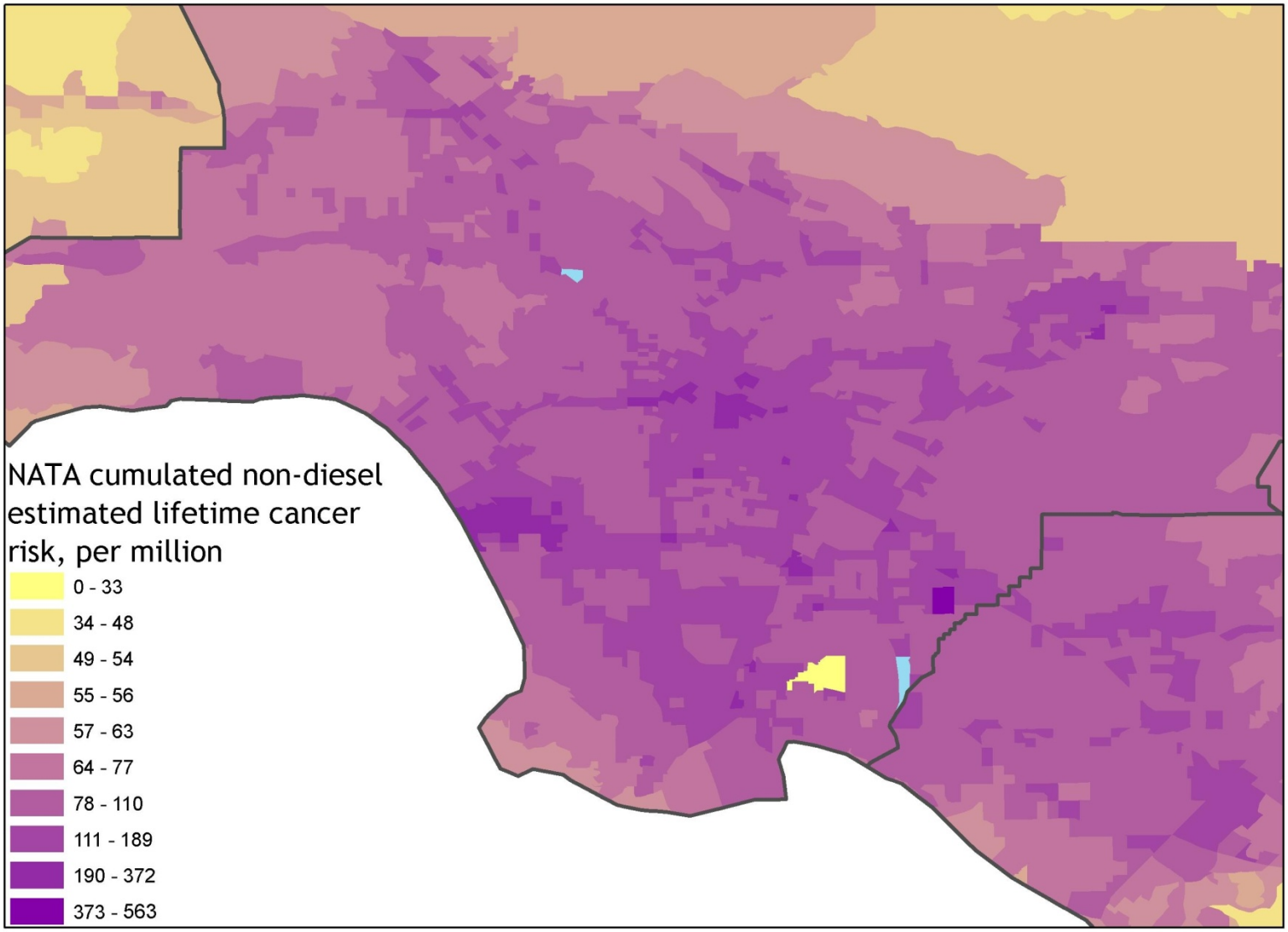
Land Use Regression of PM in LA



U.S. EPA's National Air Toxics Assessment (NATA)

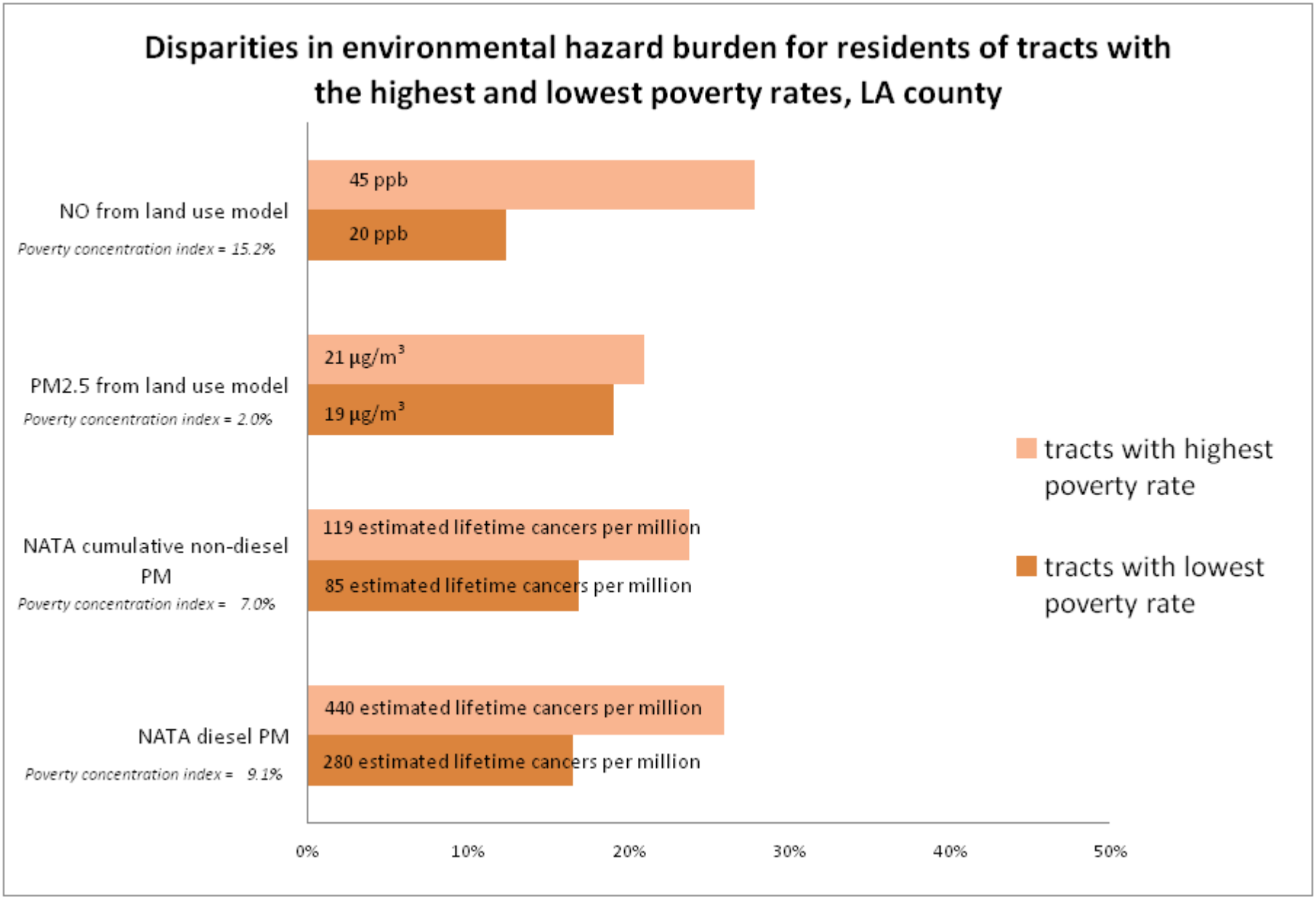
- Dispersion model estimates long-term annual average outdoor concentrations for 1999 of 32 air toxics and diesel particulates for each census tract in the US
- Model includes mobile and stationary emissions sources, including:
  - Manufacturing (e.g. refineries, factories)
  - Non-Manufacturing (e.g. dry cleaners)
  - Mobile (on road and off road)

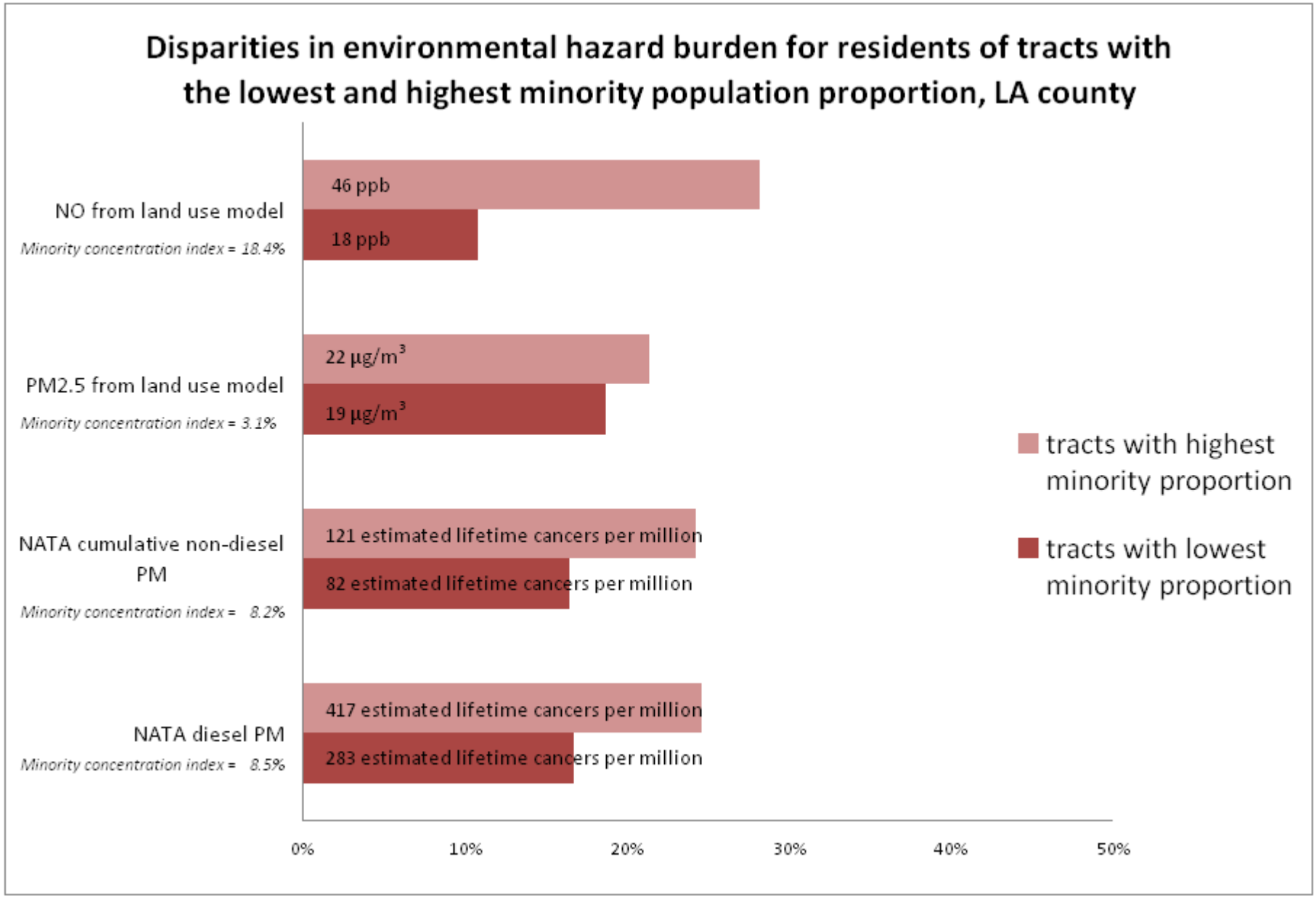

NATA diesel PM estimated
lifetime cancer risk, per million
0 - 67
68 - 106
107 - 129
130 - 168
169 - 235
236 - 350
351 - 547
548 - 886
887 - 1467
1468 - 2463


NATA cumulated non-diesel estimated lifetime cancer risk, per million
0 - 33
34 - 48
49 - 54
55 - 56
57 - 63
64 - 77
78 - 110
111 - 189
190 - 372
373 - 563

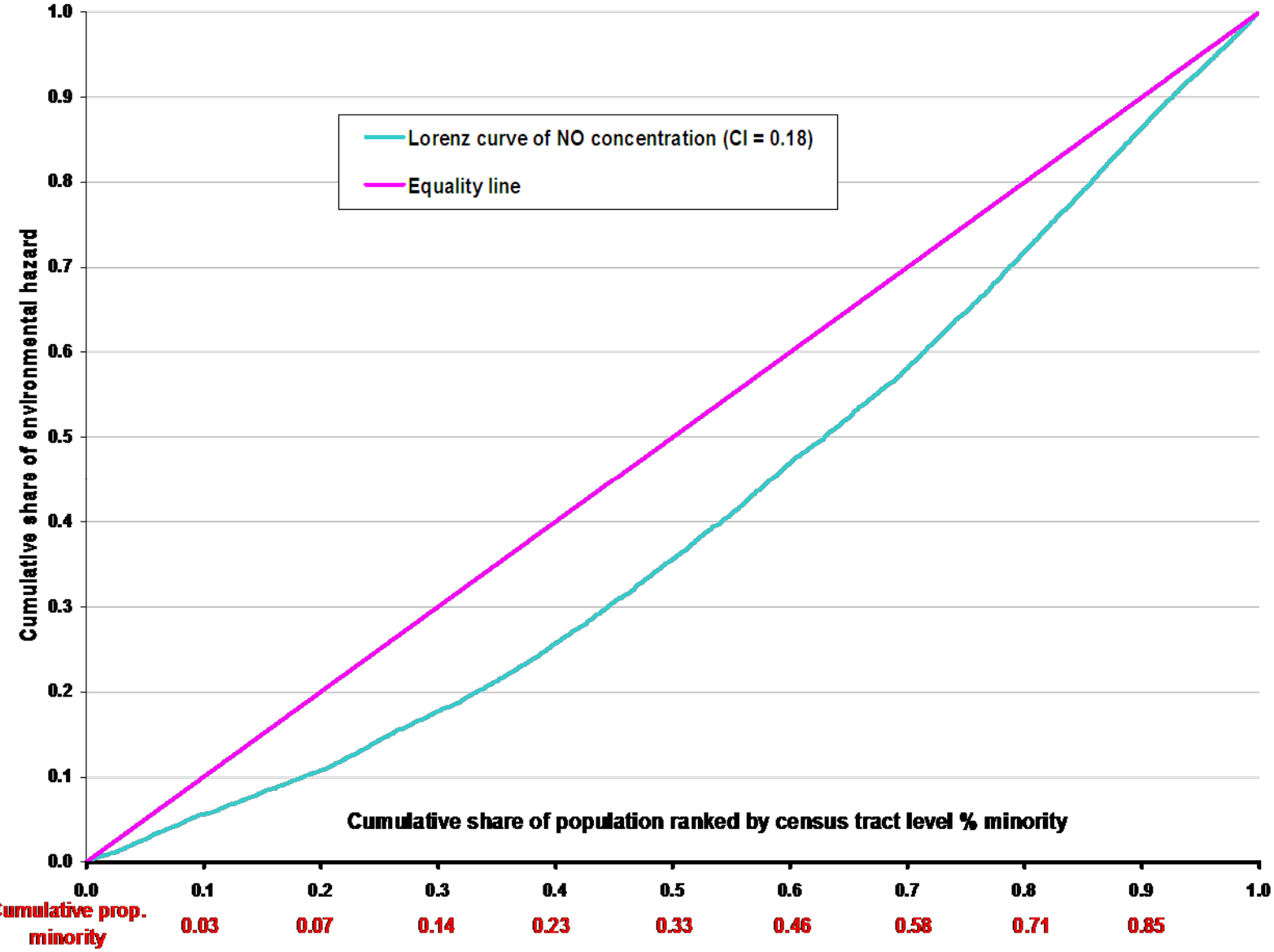
Demonstration of Analytic Method

- Inspired by Gini Coefficient/Lorenz Curve
- Indicator used widely in policy and social arenas research
- Measures relative inequality in income
- Can be adapted as an indicator of environmental inequality

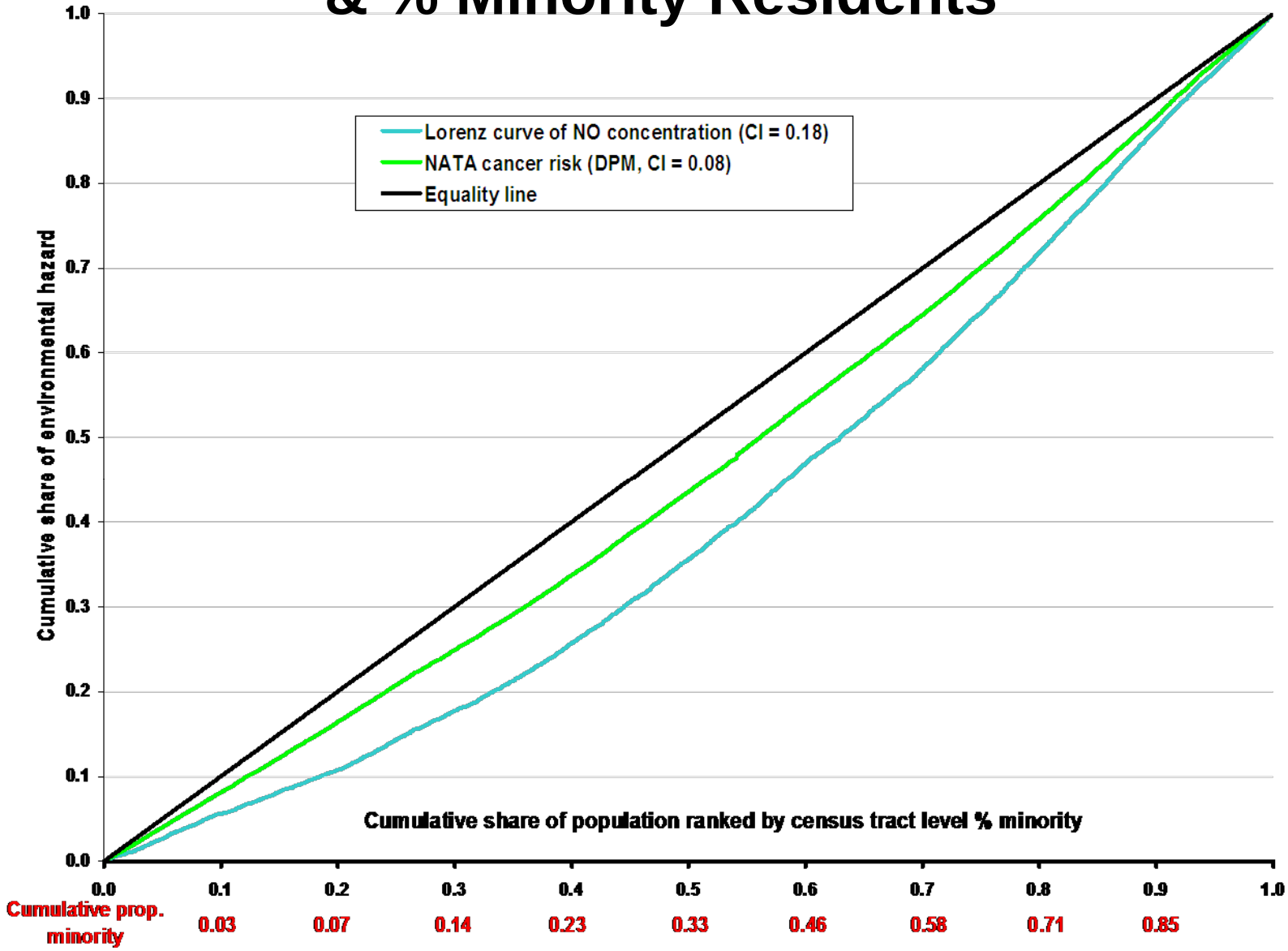

Disparities in environmental hazard burden for residents of tracts with the highest and lowest poverty rates, LA county
NO from land use model
Poverty concentration index = 15.2%
45 ppb
20 ppb
PM2.5 from land use model
Poverty concentration index = 2.0%
21 µg/m3
19 µg/m3
NATA cumulative non-diesel PM
Poverty concentration index = 7.0%
119 estimated lifetime cancers per million
85 estimated lifetime cancers per million
NATA diesel PM
Poverty concentration index = 9.1%
440 estimated lifetime cancers per million
280 estimated lifetime cancers per million
tracts with highest poverty rate
tracts with lowest poverty rate
0%
10%
20%
30%
40%
50%


Disparities in environmental hazard burden for residents of tracts with the lowest and highest minority population proportion, LA county
NO from land use model
Minority concentration index = 18.4%
46 ppb
18 ppb
PM2.5 from land use model
Minority concentration index = 3.1%
22 µg/m3
19 µg/m3
NATA cumulative non-diesel PM
Minority concentration index = 8.2%
121 estimated lifetime cancers per million
82 estimated lifetime cancers per million
NATA diesel PM
Minority concentration index = 8.5%
417 estimated lifetime cancers per million
283 estimated lifetime cancers per million
tracts with highest minority proportion
tracts with lowest minority proportion
0%
10%
20%
30%
40%
50%

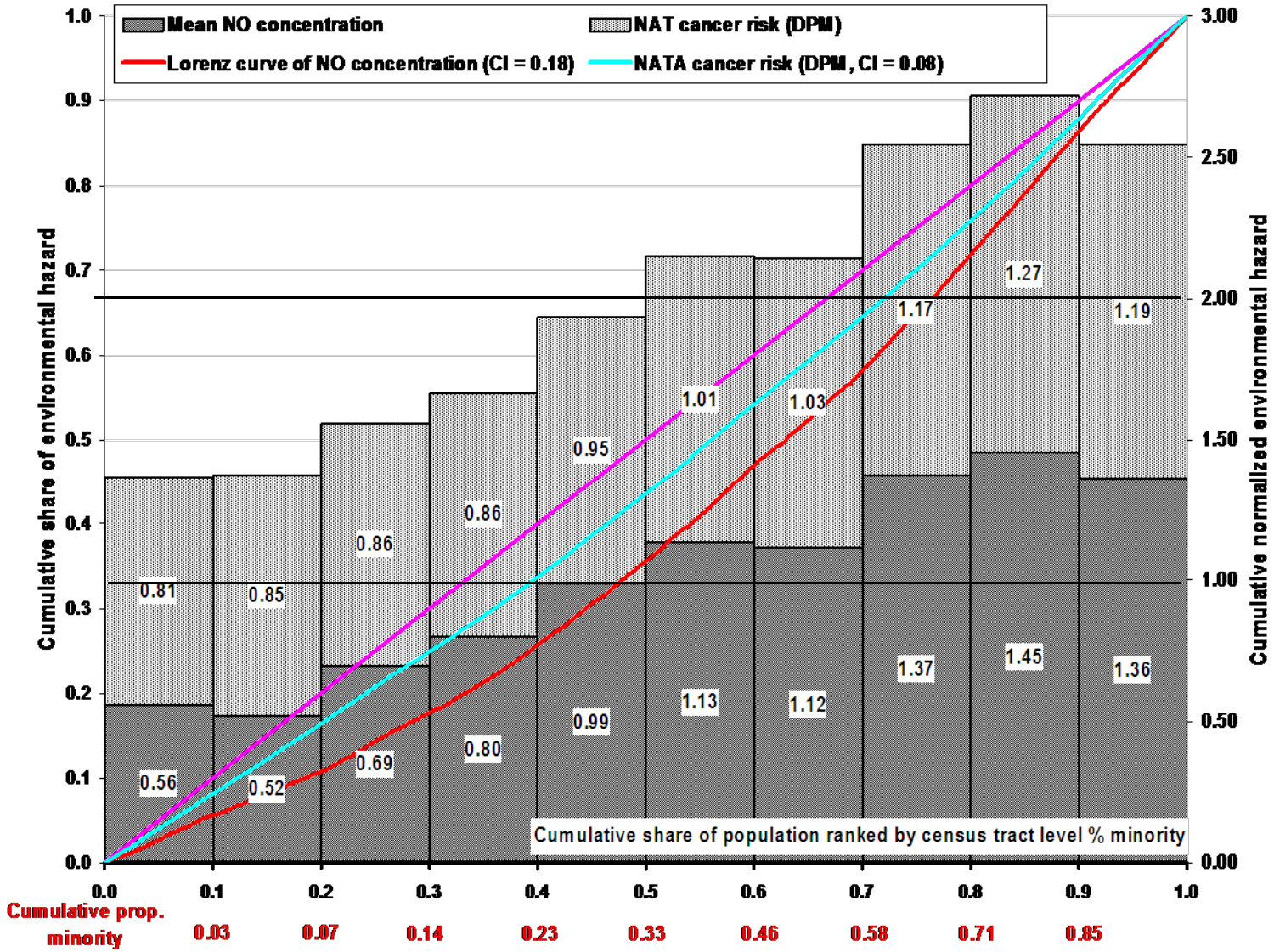
Concentration Index—
NO Concentration & % Minority Residents



Concentration Index—
NO, NATA Cancer Risk (Diesel PM)
& % Minority Residents



Concentration Index—
NO, NATA (diesel PM cancer risk) & % Minority Residents
(showing cumulative hazard)



Questions for Discussion

- What exposures would you like to see beyond air quality measures and traffic pollution?
- What indicators are most important for assessing vulnerability and susceptibility?
- What health outcomes should we focus on (cancer, mortality, birth outcomes, asthma, other?)
- What geographic locations should we examine to demonstrate methods (Los Angeles, San Diego, Bay Area, Central Valley)

Acknowledgements

- Jason Su, PhD, Bill Jesdale, PhD, Bhavna Shamasunder, PhD Candidate, UC Berkeley

- Office of Environmental Health Hazard Assessment and the California Air Resources Board